P2 1080844

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office

November 04, 2003

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY OF THE BELOW IDENTIFIED INTERNATIONAL APPLICATION AS ORIGINALLY FILED AND ANY CORRECTIONS THERETO FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE ACTING AS A RECEIVING OFFICE UNDER THE PATENT COOPERATION TREATY.

APPLICATION NUMBER: ***PCT/US02/18411***
FILING DATE: ***June 11, 2002***

By Authority of the
COMMISSIONER OF PATENTS AND TRADEMARKS

P. R. Grant

P. R. GRANT
Certifying Officer

TRANSMITTAL LETTER TO THE UNITED STATES RECEIVING OFFICE

PTO-1382 (Rev. 4-1995) (Modified) PCTUS2.FRP /REV03

Date	June 11, 2002
International Application No.	PCT/
Attorney Docket No.	P50-0830

I. Certification under 37 CFR 1.10 (if applicable)

JC09 Rec'd PCT/PTO 11 JUN 2002

EL449549068US	June 11, 2002
Express Mail mailing number	Date of Deposit

I hereby certify that the application/correspondence attached hereto is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to Assistant Commissioner for Patents, Washington, D.C. 20231.

Sylvia A Ransom	Sylvia A. Ransom
Signature of person mailing correspondence	Typed or printed name of person mailing correspondence

II. ☒ New International Application

TITLE	A METHOD FOR EMBEDDING A RADIO FREQUENCY ANTENNA IN A TIRE, AND AN ANTENNA FOR EMBEDDING IN A TIRE	Earliest priority date (Day/Month/Year)

SCREENING DISCLOSURE INFORMATION: In order to assist in screening the accompanying international application for purposes of determining whether a license for foreign transmittal should and could be granted and for other purposes, the following information is supplied. (Note: check as many boxes as apply):

A. ☐ The invention disclosed was **not** made in the United States.

B. ☒ There is no prior U.S. application relating to this invention.

C. ☐ The following prior U.S. application(s) contain subject matter which is related to the invention disclosed in the attached international application. *(NOTE: priority to these applications may or may not be claimed on form PCT/RO/101 (Request) and this listing does not constitute a claim for priority).*

application no.		filed on	
application no.		filed on	

D. ☐ The present international application ☐ is identical ☐ contains less subject matter than that found in the prior U.S. application(s) identified in paragraph C.

E. ☐ The present international application ☐ contains additional subject matter not found in the prior U.S. application(s) identified in paragraph C. above. The additional subject matter is found on pages ____ and ☐ **DOES NOT ALTER** ☐ **MIGHT BE CONSIDERED TO ALTER** the general nature of the invention in a manner which would require the U.S. application to have been made available for inspection by the appropriate defense agencies under 35 U.S.C. 181 and 37 CFR 5.1. See 37 CFR 5.15

III. ☐ A Response to an Invitation from the RO/US. The following document(s) is (are) enclosed:

A. ☐ A Request for An Extension of Time to File a Response

B. ☐ A Power of Attorney (General or Regular)

C. ☐ Replacement pages:

pages		of the request (PCT/RO/101)	pages		of the figures
pages		of the description	pages		of the abstract
pages		of the claims			

D. ☐ Submission of Priority Documents

Priority document		Priority document	

E. ☐ Fees as specified on attached Fee Calculation sheet form PCT/RO/101 annex

IV. ☐ A Request for Rectification under PCT 91 ☐ **A Petition** ☐ **A Sequence Listing Diskette**

V. ☐ Other (please specify):

The person signing this form is the:		
	☐ Applicant	Martin FARRELL
	☒ Attorney/Agent (Reg. No.) 35,506	Typed name of signer
	☐ Common Representative	Martin Farrell
		Signature

HOME COPY

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only:

International Application No. PCT/US02/18411

(11.06.02) International Filing Date 11 JUN 2002

Name of receiving Office and "PCT International Application" PCT INTERNATIONAL APPLICATION RO/US

Applicant's or agent's file reference *(if desired) (12 characters maximum)* P50-0080

Box No. I TITLE OF INVENTION

A METHOD FOR EMBEDDING A RADIO FREQUENCY ANTENNA IN A TIRE, AND AN ANTENNA FOR EMBEDDING IN A TIRE

Box No. II APPLICANT ☐ This person is also inventor

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

Societe de Technologie Michelin
23, rue Breschet
FR-63000, Clermont-Ferrand
France

Telephone No. (864) 422-4648

Facsimile No. (864) 422-3517

Teleprinter No.

Applicant's registration No. with the Office

State *(that is, country)* of nationality: FR

State *(that is, country)* of residence: FR

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☒ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

Michelin Recherche et Technique S.A.
Route Louis-Braille 10 et 12
CH-1763, Granges-Paccot
Switzerland

This person is:
☒ applicant only
☐ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality: CH

State *(that is, country)* of residence: CH

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

FARRELL, Martin
Michelin North America, Inc.
Intellectual Property Department
515 Michelin Road
Greenville, South Carolina 29605
United States of America

Telephone No. (864) 422-4648

Facsimile No. (864) 422-3517

Teleprinter No.

Agent's registration No. with the Office 35,506

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not to be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

ADAMSON, John David
101 Red Oak Court
Simpsonville, South Carolina 29681
United States of America

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

KELLY, Charles Edward
209 River Walk Court
Simpsonville, South Carolina 29681
United States of America

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

O'BRIEN, George Phillips
142 Wren School Road
Piedmont, South Carolina 29673
United States of America

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES *Mark the applicable check-boxes below; at least one must be marked.*

The following designations are hereby made under Rule 4.9(a):

Regional Patent

☒ **AP ARIPO Patent: GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **MZ** Mozambique, **SD** Sudan, **SL** Sierra Leone, **SZ** Swaziland, **TZ** United Republic of Tanzania, **UG** Uganda, **ZM** Zambia, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

☒ **EA Eurasian Patent: AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakhstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☒ **EP European Patent: AT** Austria, **BE** Belgium, **CH & LI** Switzerland and Liechtenstein, **CY** Cyprus, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **SE** Sweden, **TR** Turkey, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☒ **OA** OAPI Patent: **BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Cote d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **GQ** Equatorial Guinea, **GW** Guinea-Bissau, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line):*

☒ **AE** United Arab Emirates
☒ **AG** Antigua and Barbuda
☒ **AL** Albania .....
☒ **AM** Armenia .....
☒ **AT** Austria .....
☒ **AU** Australia .....
☒ **AZ** Azerbaijan .....
☒ **BA** Bosnia and Herzegovina .....
☒ **BB** Barbados
☒ **BG** Bulgaria .....
☒ **BR** Brazil .....
☒ **BY** Belarus .....
☒ **BZ** Belize .....
☒ **CA** Canada
☒ **CH & LI** Switzerland and Liechtenstein
☒ **CN** China .....
☒ **CO** Colombia
☒ **CR** Costa Rica .....
☒ **CU** Cuba .....
☒ **CZ** Czech Republic .....
☒ **DE** Germany .....
☒ **DK** Denmark .....
☒ **DM** Dominica
☒ **DZ** Algeria .....
☒ **EC** Ecuador .....
☒ **EE** Estonia .....
☒ **ES** Spain .....
☒ **FI** Finland .....
☒ **GB** United Kingdom
☒ **GD** Grenada
☒ **GE** Georgia .....
☒ **GH** Ghana .....
☒ **GM** Gambia
☒ **HR** Croatia .....
☒ **HU** Hungary .....
☒ **ID** Indonesia
☒ **IL** Israel .....
☒ **IN** India .....
☒ **IS** Iceland
☒ **JP** Japan .....
☒ **KE** Kenya .....
☒ **KG** Kyrgyzsta .....
☒ **KP** Democratic People's Republic of Korea .....
☒ **KR** Republic of Korea .....
☒ **KZ** Kazakhstan .....
☒ **LC** Saint Lucia
☒ **LK** Sri Lanka
☒ **LR** Liberia
☒ **LS** Lesotho .....
☒ **LT** Lithuania
☒ **LU** Luxembourg
☒ **LV** Latvia
☒ **MA** Morocco .....
☒ **MD** Republic of Moldova .....
☒ **MG** Madagascar .....
☒ **MK** The former Yugoslav Republic of Macedonia .....
☒ **MN** Mongolia
☒ **MW** Malawi .....
☒ **MX** Mexico .....
☒ **MZ** Mozambique
☒ **NO** Norway
☒ **NZ** New Zealand .....
☒ **OM** Oman
☒ **PH** Philippines .....
☒ **PL** Poland .....
☒ **PT** Portugal .....
☒ **RO** Romania
☒ **RU** Russian Federation .....
☒ **SD** Sudan
☒ **SE** Sweden
☒ **SG** Singapore
☒ **SI** Slovenia .....
☒ **SK** Slovakia .....
☒ **SL** Sierra Leone .....
☒ **TJ** Tajikistan .....
☒ **TM** Turkmenistan .....
☒ **TN** Tunisia
☒ **TR** Turkey .....
☒ **TT** Trinidad and Tobago .....
☒ **TZ** United Republic of Tanzania
☒ **UA** Ukraine .....
☒ **UG** Uganda .....
☒ **US** United States of America .....
☒ **UZ** Uzbekistan .....
☒ **VN** Viet Nam .....
☒ **YU** Yugoslavia .....
☒ **ZA** South Africa .....
☒ **ZM** Zambia
☒ **ZW** Zimbabwe .....

Check-boxes below reserved for designating States which have become party to the PCT after issuance of this sheet:

☐ ..... ☐ ..... ☐ .....
☐ ..... ☐ ..... ☐ .....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)*

Supplemental Box *If the Supplemental Box is not used, this sheet should not be included in the request.*

1. *If, in any of the Boxes, except Boxes Nos VIII(i) to (v) for which a special continuation box is provided, **the space is insufficient** to furnish all the information: in such case, write "Continuation of Box No...." (indicate the number of the Box) and furnish the information in the same manner as required according to the captions of the Box in which the space was insufficient, in particular:*

(i) ***if more than two persons are to be indicated as applicants and/or inventors** and no "continuation sheet" is available: in such case, write "Continuation of Box No. III" and indicate for each additional person the same type of information as required in Box No. III. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below;*

(ii) *if, in Box No. II or in any of the sub-boxes of Box No. III, the indication **"the States indicated in the Supplemental Box"** is checked: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the applicant(s) involved and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is applicant;*

(iii) *if, in Box No. II or in any of the sub-boxes of Box No. III, **the inventor or the inventor/applicant is not inventor for the purposes of all designated States or for the purposes of the United States of America:** in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the inventor(s) and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is inventor;*

(iv) *if, in addition to the agent(s) indicated in Box No. IV, there are **further agents**: in such case, write "Continuation of Box No. IV" and indicate for each further agent the same type of information as required in Box No. IV;*

(v) *if, in Box No. V, the name of any State (or OAPI) is accompanied by the indication **"patent of addition,"** or **"certificate of addition,"** or if, in Box No. V, the name of the United States of America is accompanied by an indication **"continuation"** or **"continuation-in-part"**: in such case, write "Continuation of Box No. V" and the name of each State involved (or OAPI), and after the name of each such State (or OAPI) , the number of the parent title or parent application and the date of grant of the parent title or filing of the parent application;*

(vi) *if, in Box No. VI, there are **more than five earlier applications whose priority is claimed**: in such case, write "Continuation of Box No. VI" and indicate for each additional earlier application the same type of information as required in Box No. VI.*

2. *If, with regard to the **precautionary designation statement** contained in Box No. V, the applicant wishes to exclude any State(s) from the scope of that statement: in such case, write "Designation(s) excluded from precautionary designation statement" and indicate the name or two-letter code of each State so excluded.*

Continuation of Box No. II

Societe de Technologie Michelin is the Applicant for all the designated states except Canada, Mexico and the United States of America.

Box No. VI PRIORITY CLAIM

The priority of the following earlier application(s) is hereby claimed:

Filing date of earlier application *(day/month/year)*	Number of earlier application	Where earlier application is:		
		national application: country	regional application:* regional Office	international application: receiving Office
item (1)				
item (2)				
item (3)				
item (4)				
item (5)				

☐ Further priority claims are indicated in the Supplemental Box.

The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of this international application is the receiving Office)* identified above as:

☐ all items ☐ item (1) ☐ item (2) ☐ item (3) ☐ item (4) ☐ item (5) ☐ other, see Supplemental Box

** Where the earlier application is an ARIPO application, indicate at least one country party to the Paris Convention for the Protection of Industrial Property or one Member of the World Trade Organization for which that earlier application was filed (Rule 4.10(b)(ii)):* .....

.....

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):*

ISA/ US.....

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority):*

Date *(day/month/year)* Number Country (*or regional Office*)

Box No. VIII DECLARATIONS

The following **declarations** are contained in Boxes Nos. VIII (i) to (v) *(mark the applicable check-boxes below and indicate in the right column the number of each type of declaration)*: Number of declarations

☐ Box No. VIII (i)	Declaration as to the identity of the inventor	:
☐ Box No. VIII (ii)	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	:
☐ Box No. VIII (iii)	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	:
☐ Box No. VIII (iv)	Declaration of inventorship (only for the purposes of the designation of the United States of America)	:
☐ Box No. VIII (v)	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	:

Box No. IX CHECK LIST; LANGUAGE OF FILING

This international application **contains:**

(a) the following number of **sheets in paper form:**

request (including declaration sheets)	:	6
description (excluding sequence listing part)	:	8
claims	:	4
abstract	:	1
drawings	:	3
Sub-total number of sheets	:	22
sequence listing part of description *(actual number of sheets if filed in paper form, whether or not also filed in computer readable form; see (b) below)*	:	
Total number of sheets	:	22

(b) sequence listing part of description filed in **computer readable form**

(i) ☐ only (under Section 801 (a)(i))

(ii) ☐ in addition to being filed in paper form (under Section 801 (a)(ii))

Type and number of carriers (diskette, CD-ROM, CD-R or other) on which the sequence listing part is contained *(additional copies to be indicated under item 9(ii), in right column)*: .....

This international application is **accompanied by** the following item(s) *(mark the applicable check-boxes below and indicate in right column the number of each item)*:

	Number of items
1. ☒ fee calculation sheet	1
2. ☐ original separate power of attorney	
3. ☐ original general power of attorney	
4. ☒ copy of general power of attorney; reference number, if any:	2
5. ☐ statement explaining lack of signature	
6. ☐ priority document(s) identified in Box No. VI as item(s):	
7. ☐ translation of international application into *(language)*:	
8. ☐ separate indications concerning deposited microorganism or other biological material	
9. ☐ sequence listing in computer readable form (indicate also type and number of carriers (diskette, CD-ROM, CD-R or other))	
(i) ☐ copy submitted for the purposes of international search under Rule 13*ter* only (and not as part of the international application)	
(ii) ☐ *(only where check-box (b)(i) or (b)(ii) is marked in left column)* additional copies including, where applicable, the copy for the purposes of international search under Rule 13*ter*	
(iii) ☐ together with relevant statement as to the identity of the copy or copies with the sequence listing part mentioned in left column	
10. ☐ other *(specify)*:	

Figure of the drawings which should accompany the abstract: Figure 1

Language of filing of the international application: English

Box No. X SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

Martin Farrell

FARRELL, Martin Agent
Reg. No. 35,506

(11.06.02)

For receiving Office use only

1. Date of actual receipt of the purported international application:	JC09 Rec'd PCT/PTO 11 JUN 2002	2. Drawings: ☑ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:		
4. Date of timely receipt of the required corrections under PCT Article 11(2):		
5. International Searching Authority (if two or more are competent): ISA/US	6. ☐ Transmittal of search copy delayed until search fee is paid	

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

PCT/US 02/18411
RO/US 23 JUL 2002

PCT

POWER OF ATTORNEY

(for an international application filed under the Patent Cooperation Treaty)

(PCT Rule 90.4)

The undersigned applicant(s) *(Names should be indicated as they appear in the request):*

ADAMSON, John David
KELLY, Charles Edward
O'BRIEN, George Phillips

hereby appoints (appoint) the following person as: ☒ agent ☐ common representative

Name and address
(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

FARRELL, Martin
Michelin North America, Inc.
Intellectual Property Department
515 Michelin Road
Greenville, South Carolina 29605
United States of America

to represent the undersigned before

☒ all the competent International Authorities
☐ the International Searching Authority only
☐ the International Preliminary Examining Authority only

in connection with the international application identified below:

Title of the invention: A METHOD FOR EMBEDDING A RADIO FREQUENCY ANTENNA IN A TIRE, AND AN ANTENNA FOR EMBEDDING IN A TIRE

Applicant's or agent's file reference: P50-0080

International application number (if already available): PCT/US02/18411

filed with the following Office United States Patent and Trademark Office as receiving Office and to make or receive payments on behalf of the undersigned.

Signature of the applicant(s) *(where there are several applicants, each of them must sign; next to each signature, indicate the name of the person signing and the capacity in which the person signs, if such capacity is not obvious from reading the request or this power):*

ADAMSON, John David

O'BRIEN, George Phillips

KELLY, Charles Edward

Date: June 24 2002

This sheet is not part of and does not count as a sheet of the international application.

PCT

FEE CALCULATION SHEET

Annex to the Request

For receiving Office use only

International PCT/US02/18411

(11.06.02)

Date stamp of the receiving Office 11 JUN 2002

Applicant's or agent's file reference **P50-0080**

Applicant

Societe de Technologie Michelin, Michelin Recherche et Technique S.A.

CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE	240.00 T	240.
2. SEARCH FEE	700.00 S	700.

International search to be carried out by **RO/US**

(If two or more International Searching Authorities are competent to carry out the international search, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FEE

Basic Fee

Where item (b) of Box No. IX applies, enter **Sub-total number of sheets** / Where item (b) of Box No. IX does not apply, enter **Total number of sheets**: **22**

b1 first 30 sheets	407.00 b1	407.
b2 0 (number of sheets) x ____ (fee per sheet) =	0.00 b2	—
b3 additional component (only if sequence listing part of description is filed in computer readable form under Section 801(a)(i), or both in that form and on paper, under Section 801(a)(ii)): 400 x ____ (fee per sheet) =	b3	
Add amounts entered at b1, b2 and b3 and enter total at B	407.00 B	407.

Designation Fees

The international application contains 115 designations.

5 (number of designation fees payable *(maximum 5)*)	x	88.00 (amount of designation fee)	= 440.00 D	440.
Add amounts entered at B and D and enter total at I			847.00 I	847.

(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled, the

4. FEE FOR PRIORITY DOCUMENT *(if applicable)*	0.00 P	—
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A METHOD FOR EMBEDDING A RADIO FREQUENCY ANTENNA IN A TIRE, AND AN ANTENNA FOR EMBEDDING IN A TIRE

BACKGROUND AND SUMMARY

Electronic devices integrated in a tire provide functions such as identification and tracking during manufacture, distribution, and use, and measurement of physical parameters such as pressure and temperature during use of the tire. Many systems utilize radio frequency communication between the tire and the external monitoring or interrogating device. A radio frequency communication link requires one or more antennas.

There are available systems that mount to a surface of the tire or the wheel, or are incorporated in the tire inflation valve. An electronic device and antenna embedded in a tire structure, that is, in the rubber material, is desirable as providing a permanent, tamper-proof integration. Embedding the antenna in the tire, however, presents difficulties. The antenna must radiate radio frequency through the surrounding elastomeric material, which is usually electrically conductive, and which has a relatively high dielectric constant, typically 3 or greater. Conductive material in contact with an antenna tends to dissipate the radio frequency energy traveling on the antenna surface. In addition, conductive dielectric material in contact with an antenna allows radio frequency current to pass between the two adjacent feed points of the antenna, also dissipating radio frequency energy. The problem of dissipation increases with the frequency, and is particularly troublesome at or above very high frequency (130 MHz) operation.

In addition, the antenna, typically a metallic element, must adhere to the rubber material to secure it in place.

The invention provides a method for embedding a radio frequency antenna in a conductive elastomeric material, such as tire rubber, that allows for very high frequency or higher radio transmission from the antenna. According to the invention, the method comprises the steps of forming an antenna element, coating the antenna element with an insulating coating, the coating having a dielectric

constant lower than a dielectric constant of the elastomeric material and embedding the coated antenna element in the elastomeric material. Preferably, the coating is formed at least 0.2 mm thick, and more preferably, at least 0.3 mm thick.

According to another aspect of the invention, the coating material preferably has a surface resistivity of at least 10^{14} ohms/sq and a volume resistivity of at least 10^{11} ohms*cm. In addition, the coating material preferably has a dissipation factor less than 0.03.

According to another aspect of the invention, the antenna is tuned to compensate for the effect the dielectric elastomeric material has on the resonant frequency of the embedded antenna. The dielectric has the effect of making the antenna appear electrically longer than its physical length. The antenna, accordingly, is shortened, which is done by a series of iterations to determine the optimum length alone or with the aid of a network analyzer. Alternatively, the antenna could be adjusted by adding capacitive reactance in series at the feedpoint.

The invention also provides an antenna for embedding in rubber material of a tire suitable for transmission in a frequency range of at least 130 MHz. According to this aspect of the invention, an antenna includes an antenna body and an insulating coating surrounding the antenna body, the insulating coating having a dielectric constant less than a dielectric constant of the rubber material, and preferably less than 3, and having a thickness of at least 0.2 mm.

The antenna body can be any body capable of transmitting radio frequency energy. Advantageously, and preferably for use in a tire because of its durability under fatigue conditions, the antenna body is a wire formed of spring steel, brass coated spring steel, or spring brass. Such materials are capable of surviving the bending and flexing deformations typically experienced by the tire.

According to the invention, the coating material preferably has a surface resistivity of at least 10^{14} ohms/sq and a volume resistivity of at least 10^{11}

ohms*cm. In addition, the coating material preferably has a dissipation factor less than 0.03.

The invention will be better understood by reference to the following detailed description in conjunction with the appended drawings.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

Figure 1 is a schematic of an electrical device having an antenna in accordance with the invention;

Figure 2 is a sectional view of a tire showing alternative placements for an electrical device with an antenna in accordance with the invention;

Figure 3 is a graph showing the effect of various insulating materials on the ability of a coated antenna to transmit through tire rubber material at 915 MHz;

Figure 4 is a graph showing the adherence strength of various coating materials; and

Figure 5 is a graph showing results of tuning an antenna and embedding it in an elastomeric material.

DETAILED DESCRIPTION

Illustrated in Figure 1 is a radio frequency device 10 for a tire including a radio device 11 and an antenna 12 in accordance with the invention. The radio device 11 itself may be an identification or tracking device, such as may be used in manufacturing, distribution, and sale activities. The device 11 may also be a monitoring device for measuring temperature, pressure or other physical parameters in an operating tire. For example, the antenna 12 in such a device is used to transmit to and/or receive from an external device information by radio frequency. As another example, the antenna may also serve to receive energy from an interrogation device. Such radio devices may operate as receivers,

transmitters, transponders or reflectors, and, because the antenna of the invention is useful for all these devices, in the following description, the term "radio device" is intended to be inclusive.

As shown in Figure 2, advantageously, the radio frequency device 10 may be positioned in a number of different places in a tire. A single tire may include one or several such devices, for example, if it is desired to monitor physical parameters at different locations in the tire or to monitor different parameters. The device 11 and antenna 12 may be embedded in a rubber patch 30 which is adhered to a surface of a tire 14. Alternatively, the radio device 11 and antenna 12 may be embedded in the tire structure itself or layered under rubber material in the tire 14 which forms a surface. For example, the radio frequency device 10 may be positioned between the carcass ply 16 and the inner liner 15, between the carcass play 16 and the sidewall 17, and/or between the belt package 18 and the tread 19. By "integrated" the inventors refer to either manner of incorporating the antenna 12 and radio device 11 in a tire.

Tire rubber material is usually electrically conductive, usually as a result of carbon black and other reinforcing fillers. Direct contact between a radio frequency antenna and tire rubber material is thus deleterious to the ability of the antenna to transmit energy. Radio frequency energy travels along the surface of an antenna, in the so-called "skin effect." Conductive material in contact with the surface of the antenna tends to dissipate the energy through eddy currents. In addition, the conductive dielectric material allows radio frequency energy to pass between the two adjacent feed points of the antenna, which also dissipates energy. The result is a decrease in the effective transmission distance of the antenna. The inventors found that a device comprising a 915 MHz RFID chip having an antenna with a half-wavelength dipole length of 83 mm had a transmission range of 42 inches in air. When embedded in conventional tire rubber, the device had a transmission range of only 4 inches.

To overcome loss of effective range, the antenna 12 in accordance with the invention includes an antenna element 20 or body and an insulating coating 22. The embodiment shown in Figure 1 illustrate the antenna 20 as having a

sinusoidal form, which is advantageous for accommodating tensile forces in the tire material present in tire manufacturing operations and in normal tire operation. The antenna element 20 can be any element capable of transmitting radio frequency energy. For example, and preferably for use in a tire, the antenna element 20 is a wire formed of spring steel, brass coated spring steel, or spring brass. Such materials are able to withstand the kind of stresses experienced by a tire structure.

The coating layer 22 is formed of an insulating material and is at least 0.02 mm thick as measured perpendicular to the antenna. The thickness is sufficient to provide spacing between the conductive elastomeric material and the antenna 20 for avoiding bleed-through discharges to the elastomeric material. According to the invention, the coating material has a dielectric constant less than that of the elastomeric material, and preferably less than 3. In addition, the coating material preferably has a surface resistivity of at least 10^{14} ohms/sq and a volume resistivity of at least 10^{11} ohms*cm. Further, the coating material preferably has a dissipation factor less than 0.03.

The inventors have found materials useful for forming the coating material to include electrical shrink tubing, thermoplastic polycarbonate, butadiene rubber, an isocyanate-based rubber to metal adhesive such as Chemlok (brand) TS3604-50 adhesive (available from Lord Corporation, Chemical Products Division, 2000 West Grand View Boulevard, Erie, Pennsylvania), polyethylene, insulating varnish, epoxy, TPE cellulose acetate, polypara-xylylene (commonly known as "parylene"), and insulating polyester varnish. Such materials have certain advantages, including the ability to apply in the needed thickness. In addition, these coating materials have good adherence with both the antenna material (brass or steel in the described embodiment) and the rubber material of the tire or patch. Thus, an adhesive is not needed.

Figure 3 shows the results of exemplary antennas made with various insulating coating materials and embedded in a rubber substrate to simulate incorporation in a tire. The antennas were attached to a 915MHz RFID chip which acted as a transponder. As may be seen from the figure, an uncoated antenna

had a read range of about 4 inches. A first group, including shrink tubing, thermoplastic polycarbonate, butadiene rubber, and Chemlok (brand) TS3604-50 adhesive extended the read range to at least 35 inches. A second group, including insulating varnish, epoxy, TPE cellulose acetate, parylene, and insulating polyester varnish achieved lesser gains, but all were at least double the read range. Upon inspection, it was found that the second group had cracks in the insulation or other deficiencies in the thickness of the coating. The inventors believe that a coating thickness of at least 0.2 mm is sufficient to obtain a significant gain in read range, with a thickness of at least 0.3 mm being preferred.

According to another aspect of the invention, the insulating coating acts as an adhesive to bond the antenna to the rubber material. That is, the insulating coating has good adherence to both the antenna material and the tire rubber material. This aspect of the invention simplifies the manufacturing process by eliminating the need for one or two adhesives and the associated application steps. It is not critical, however, that the insulating coating perform this function, and the use of a separate adhesive is within the scope of the invention.

Figure 4 illustrates the results of testing various insulating coatings for adhesion strength in bonding an antenna wire having a brass outer layer (spring brass or brass coated spring steel) in tire rubber. Sample antenna wires were prepared, including an uncoated wire, and wires having, respectively, coatings of a rubber mix used for tire belts, Chemlok TS3604-50 (brand) adhesive, silica rubber, butadiene rubber, parylene C, parylene N, Bayer 9371 (brand) thermoplastic polycarbonate, and Bayer 2608 (brand) thermoplastic polycarbonate (available from Bayer Corporation, 100 Bayer Road, Pittsburgh, Pennsylvania 15205). These prepared antenna wires were cured in a sandwich of sidewall type rubber and carcass ply rubber mix. After cure, a peel test was done, with the resulting force needed to peel the rubber from the antennas shown in Figure 4. The highest peel forces were achieved by the antenna wires coated with belt rubber mix, Chemlok (brand) TS3604-50 adhesive, silica rubber, and the bare wire in a sidewall rubber.

By comparing the results shown in Figure 3 and Figure 4, it is noted that Chemlok (brand) TS3604-50 adhesive had the best combination of insulating characteristic (improvement in read range) and adhesive ability (peel strength).

A further step of preparing an antenna for use in a tire or in a rubber substrate involves re-tuning the antenna to adjust for the effect of embedding it in a dielectric material. Figure 5 shows the results of a test of antennas coated with standard electrical heat shrink tubing, cut to various lengths, and embedded in a typical cured and uncured tire sidewall rubber mix. Again, the antennas were connected to a 915 MHz RFID chip as the transponder. The horizontal axis shows the half-wavelength dipole length of the antenna in millimeters The vertical axis shows the read range in inches. As may be seen, an antenna in free air (not embedded in rubber) has a read range of about 48 inches with a half-wavelength dipole length of 83 mm. In an uncured rubber mix, the same length antenna had a read range of about 30 inches. In a cured rubber mix, the antenna had a read range of 12 inches. Tuning the half-wavelength dipole length to 47 mm restored the read range to 41 inches, and as shown, was the optimum for this configuration.

Tuning may be accomplished through iterations as suggested by Figure 5. Alternatively, a network analyzer could be used to determine the actual resonant frequency of the antenna embedded in the particular rubber to reduce the iterations required to find the optimum length.

Alternatively, the antenna could be adjusted by adding capacitive reactance in series between the antenna and the device at the feedpoint.

A method to embed an antenna in a tire or an elastomeric substrate according to the invention includes the steps of forming an antenna body, coating the body with an insulating coating at least 0.2 mm, and more preferably 0.3 mm thick, and curing the coated antenna body in an elastomeric material. According to a further step, the antenna wire is tuned prior to being embedded in the rubber material according to the procedure described above. Further, the coating material is selected in accordance with the properties described above.

The step of coating the antenna body could be accomplished by repeated dipping steps to build up the coating to the desire layer. Alternatively, the coating could be applied by spraying or other known techniques for applying coatings to wire-like materials.

The invention has been described in terms of preferred principles, embodiments, and structures for the purposes of description and illustration. Those skilled in the art will understand that substitutions may be made and equivalents found without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. A radio frequency antenna for operation in a frequency range of at least 130 MHz for embedding in rubber material of a tire, comprising:

an antenna body; and,

an insulating coating surrounding the antenna body, the insulating coating having a dielectric constant less than a dielectric constant of the rubber material.

2. The radio frequency antenna as claimed in claim 1, wherein the coating is at least 0.2 mm thick.

3. The radio frequency antenna as claimed in claim 2, wherein the coating is at least 0.3 mm thick.

4. The radio frequency antenna as claimed in claim 1, wherein dielectric constant of the insulating coating is less than 3.

5. The radio frequency antenna as claimed in claim 1, wherein the coating material has a surface resistivity of at least 10^{14} ohms/sq, a volume resistivity of at least 10^{11} ohms*cm, and a dissipation factor less than 0.03.

6. The radio frequency antenna as claimed in claim 1, wherein the coating material is selected from a group comprising electrical shrink tubing, thermoplastic polycarbonate, butadiene rubber, isocyanate based adhesive, polyethylene, insulating varnish, epoxy, TPE cellulose acetate, parylene, and insulating polyester varnish.

7. A tire having a radio frequency antenna integrated therein, the tire comprising a carcass reinforcement and rubber material layers applied to said carcass, the antenna comprising:

an antenna body; and,

an insulating coating surrounding the antenna body, the insulating coating having a dielectric constant less than a dielectric constant of the rubber material.

8. The tire having a radio frequency antenna as claimed in claim 7, wherein the insulating coating is at least 0.2 mm thick.

9. The tire having a radio frequency antenna as claimed in claim 7, wherein the insulating coating is at least 0.3 mm thick.

10. The tire having a radio frequency antenna as claimed in claim 7, wherein dielectric constant of the insulating coating is less than 3.

11. The tire having a radio frequency antenna as claimed in claim 7, wherein the coating material has a surface resistivity of at least 10^{14} ohms/sq, a volume resistivity of at least 10^{11} ohms*cm, and a dissipation factor less than 0.03.

12. The tire having a radio frequency antenna as claimed in claim 7, wherein the coating material is selected from a group comprising electrical shrink tubing, thermoplastic polycarbonate, butadiene rubber, isocyanate based adhesive, polyethylene, insulating varnish, epoxy, TPE cellulose acetate, parylene, and insulating polyester varnish.

13. The tire having a radio frequency antenna as claimed in claim 7, wherein the antenna is embedded in a rubber patch adhered to a surface of the tire.

14. The tire having a radio frequency antenna as claimed in claim 7, wherein the antenna is embedded in a structural portion of the tire.

15. A tire having a radio frequency device integrated therein, the tire comprising a carcass reinforcement and rubber material layers applied to said carcass, the radio frequency device comprising:

a radio device which operates at a frequency of at least 130 MHz;

an antenna body connected to the transponder; and,

an insulating coating at least 0.2 mm thick surrounding the antenna body, the insulating coating having a dielectric constant less 3, a surface resistivity of at least 10^{14} ohms/sq, a volume resistivity of at least 10^{11} ohms*cm, and a dissipation factor less than 0.03.

16. The tire having a radio frequency antenna as claimed in claim 15, wherein the radio frequency device is embedded in a rubber patch adhered to a surface of the tire.

17. The tire having a radio frequency antenna as claimed in claim 15, wherein the radio frequency device is embedded in a structural portion of the tire.

18. A method for embedding a radio frequency antenna in conductive elastomeric material, comprising the steps of:

forming an antenna element;

coating the antenna element with an insulating coating, the coating having a dielectric constant lower than a dielectric constant of the elastomeric material, the coating being formed at least 0.2 mm thick; and,

embedding the coated antenna element in the elastomeric material.

19. The method as claimed in claim 18, wherein, the coating material has a surface resistivity of at least 10^{14} ohms/sq, a volume resistivity of at least 10^{11} ohms*cm, and a dissipation factor less than 0.03.

20. The method as claimed in claim 18, wherein the coating material has a thickness of at least 0.3 mm.

21. The method as claimed in claim 18, wherein the coating material is selected from a group comprising electrical shrink tubing, thermoplastic polycarbonate, butadiene rubber, isocyanate based adhesive, polyethylene, insulating varnish, epoxy, TPE cellulose acetate, parylene, and insulating polyester varnish.

22. The method as claimed in claim 18, further comprising the step of tuning the antenna for resonant frequency for the elastomeric material.

23. The method as claimed in claim 18, wherein the elastomeric material is a rubber patch, and further comprising the step of adhering the patch to a surface of a tire.

24. The method as claimed in claim 18, wherein the elastomeric material is a portion of a tire.

ABSTRACT

A radio frequency antenna for use with a radio device embedded in a tire for operation in a frequency range of at least 130 MHz, comprises an antenna body, and an insulating coating surrounding the antenna body, the insulating coating having a dielectric constant less than a dielectric constant of the rubber material, and preferably less than 3, and having a thickness of at least 0.2 mm. The coating material preferably has a surface resistivity of at least 10^{14} ohms/sq and a volume resistivity of at least 10^{11} ohms*cm. In addition, the coating material preferably has a dissipation factor less than 0.03. The antenna body is preferably a wire formed of spring steel, brass coated spring steel, or spring brass.

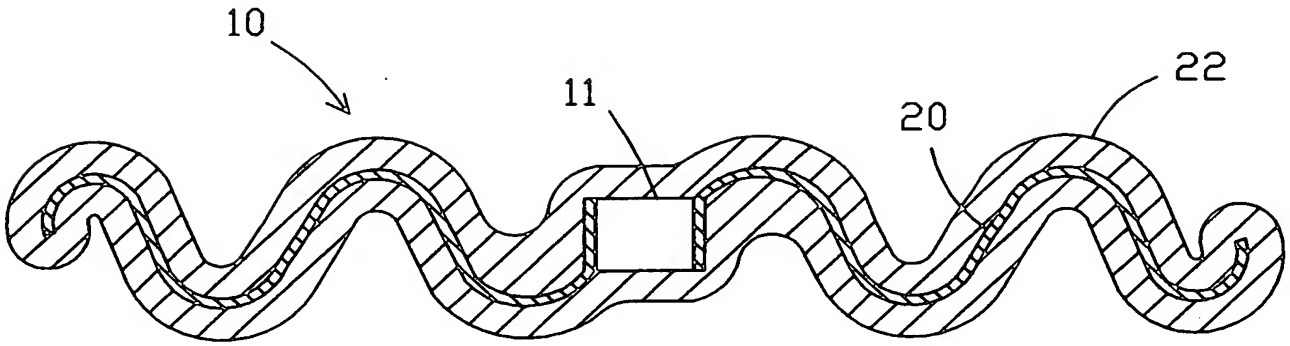

Figure 1

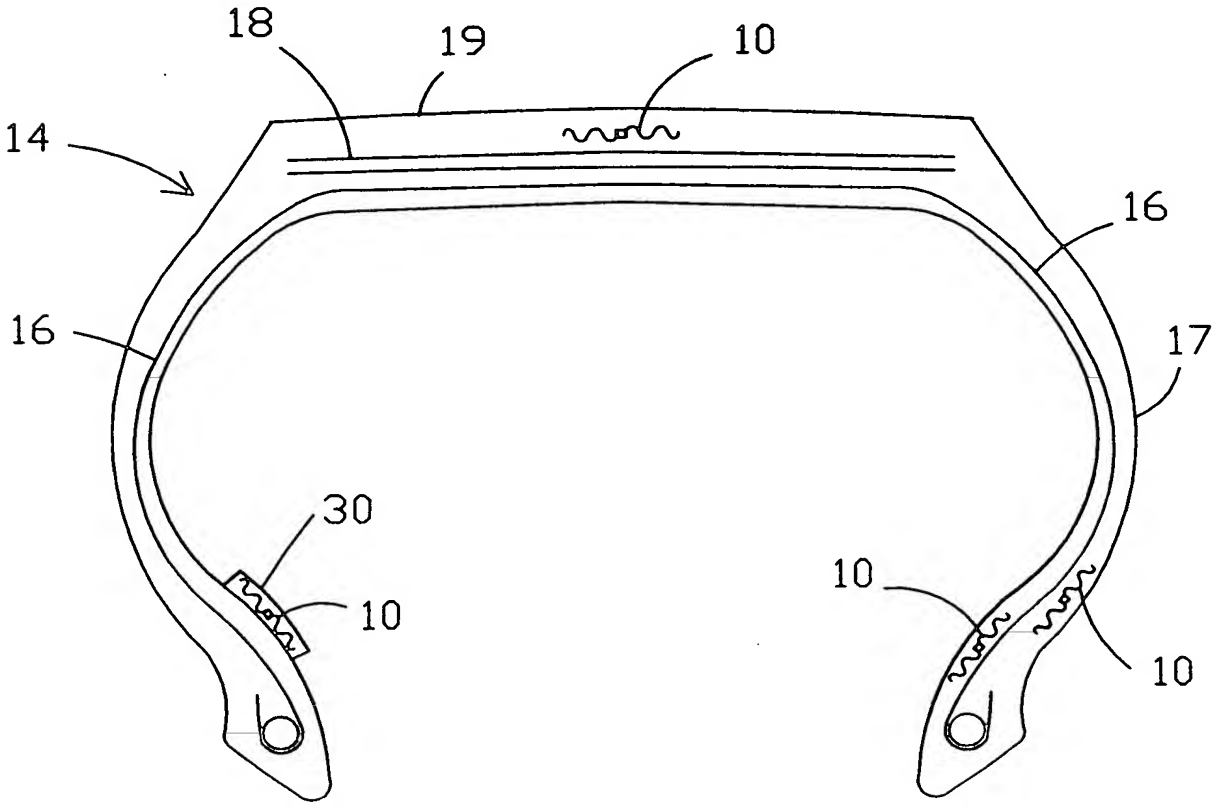

Figure 2

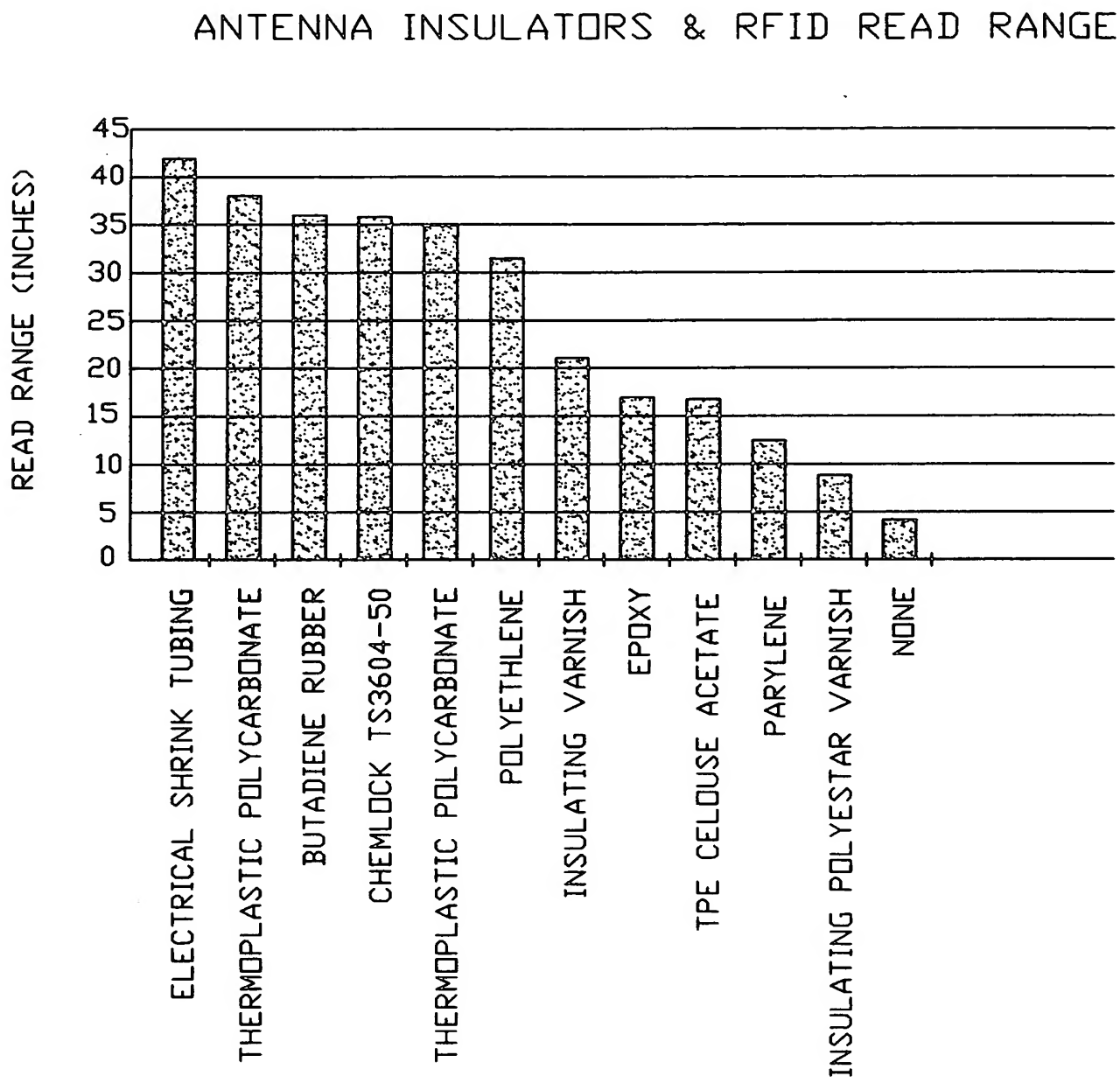

Figure 3

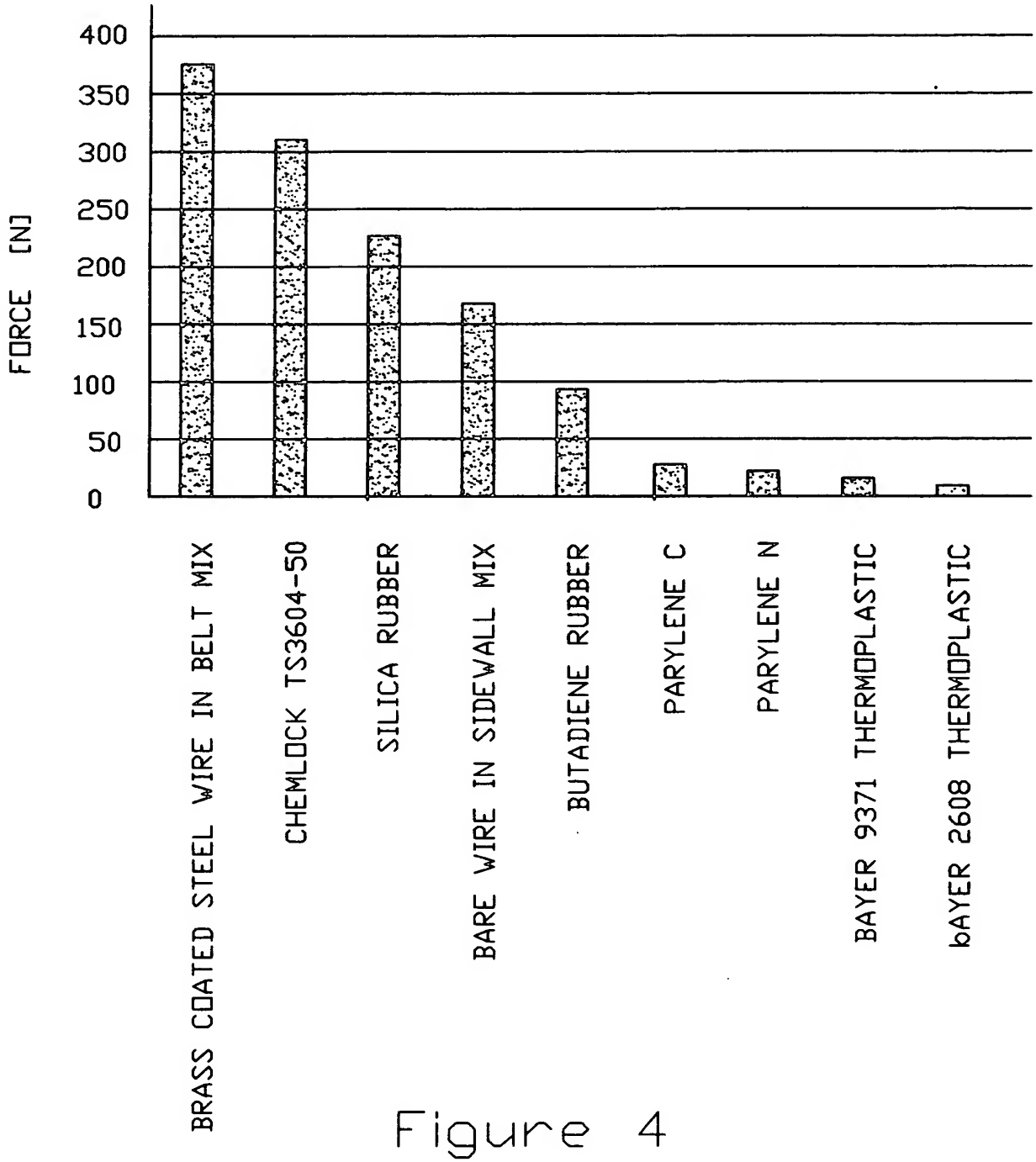

Figure 4

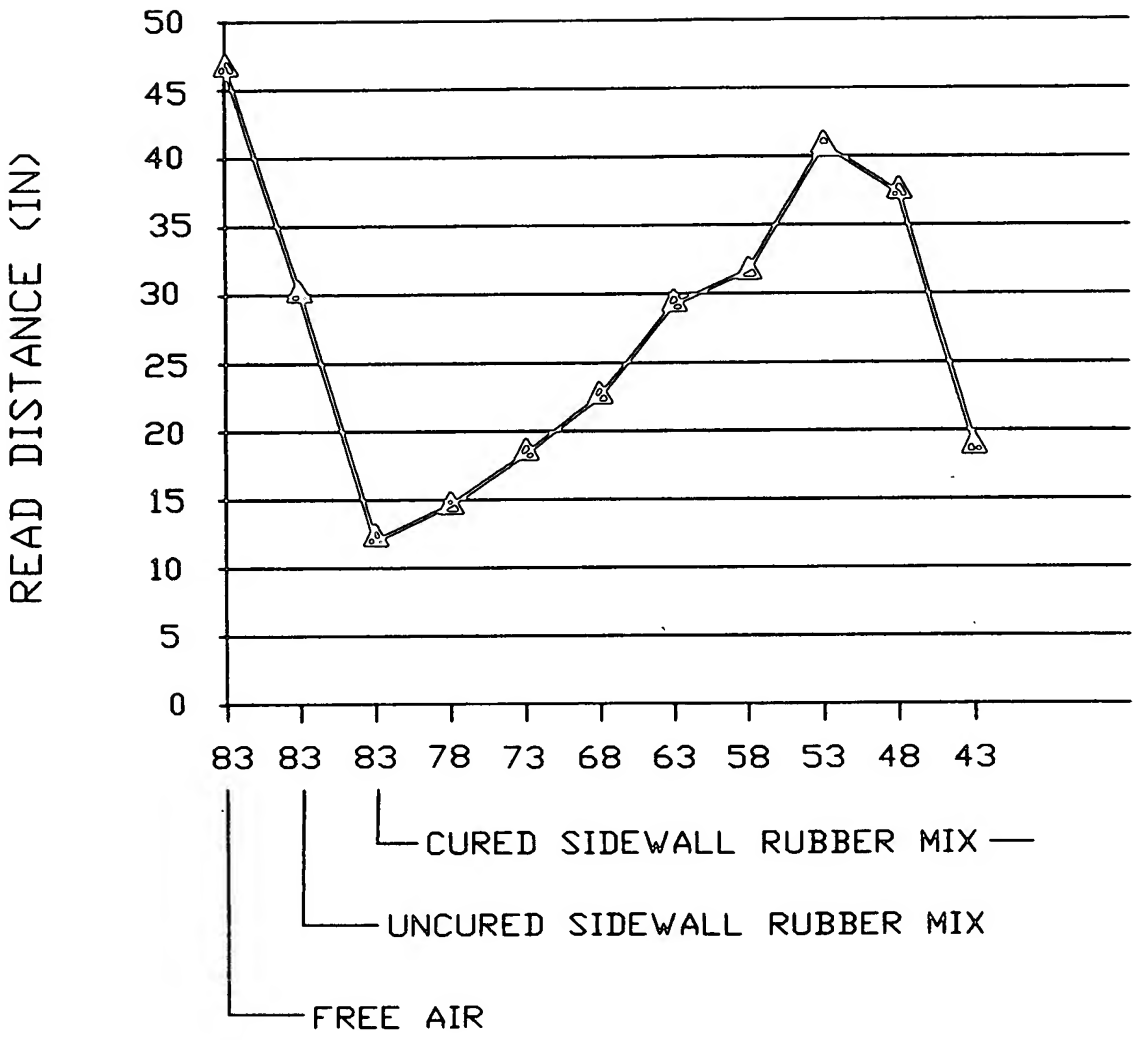

Figure 5